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Heterogeneous photo-Fenton oxidation of methylene blue solution using Fe(II)-montmorillonite calcinated clay catalyst

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Introduction

Contributes to fulfilling the basic living (clothing) requirements of human life;

The wastewater discharged from textile dyeing industry contains a total of 72 toxic chemicals, out of which 30 chemicals cannot be removed by waste treatment processes;

Formation of many types of cancers of different organs such as bladder, spleen, liver and normal aberrations in model organisms and chromosomal deformities in mammalian cells;

Textille dyes are characterized by high color density, high concentration of recalcitrante organics and pH and high turbidity.

Water Environment Federation

Textiles wastewater treatment technology: A review

Dongyang Deng [1,*], Mehdi Lamssali [1], Niroj Aryal [2], Andrea Ofori-Boadu [1], Manoj K. Jha [3], Raymond E. Samuel [4]

CRITICAL REVIEWS IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY
2017, VOL. 47, NO. 19, 1836–1876
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Biological methods for textile dye removal from wastewater: A review

Deepika Bhatia[a], Neeta Raj Sharma[a], Joginder Singh[a], and Rameshwar S. Kanwar[a,b]

[a]Department of Biotechnology, School of Bioengineering and Biosciences Lovely Professional University, Phagwara, Punjab, India; [b]Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, Iowa, USA

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Review article

Textile finishing dyes and their impact on aquatic environs

Mohamed Berradi [a,**], Rachid Hsissou [a,b,*], Mohammed Khudhair [c], Mohammed Assouag [b], Omar Cherkaoui [d], Abderrahim El Bachiri [e], Ahmed El Harfi [a]

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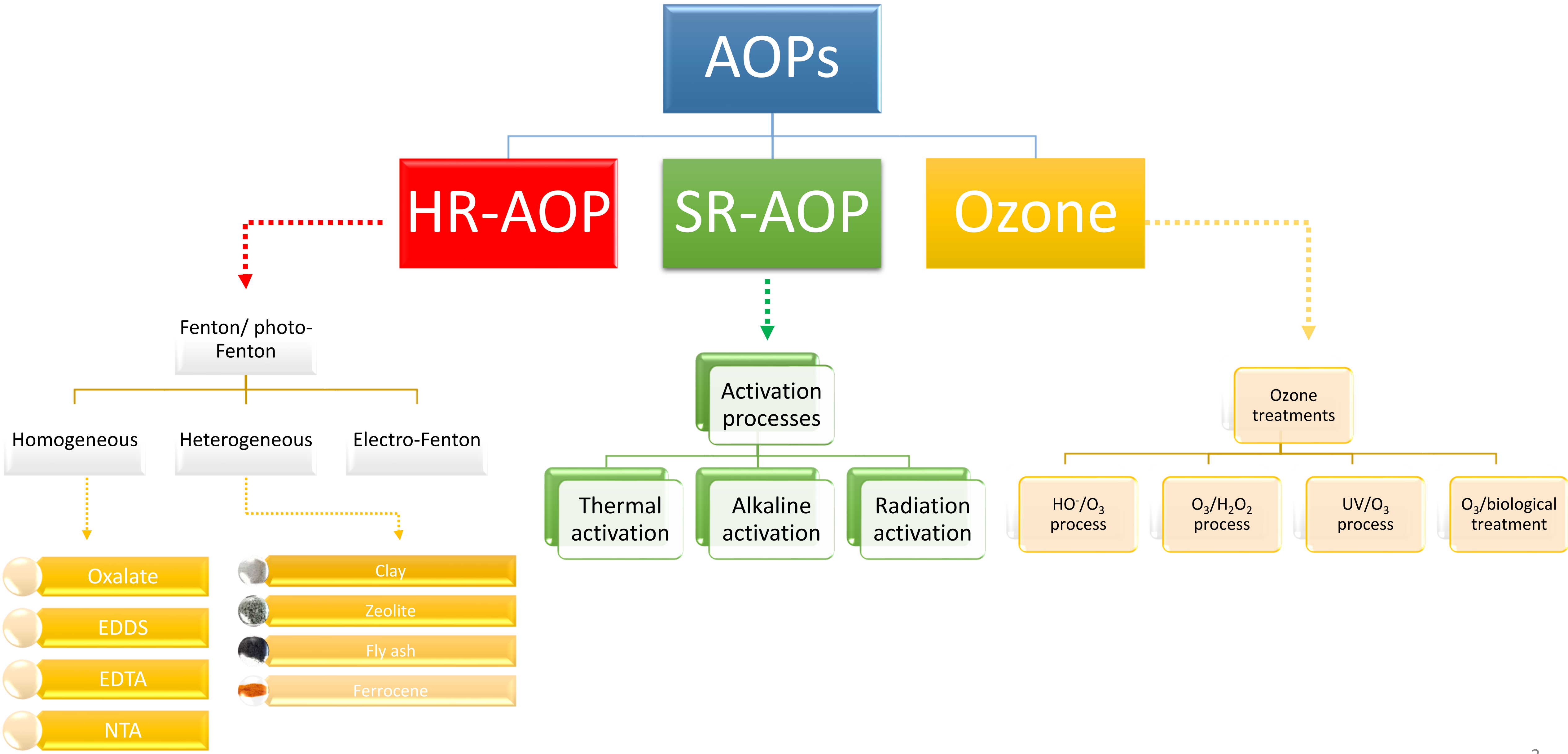
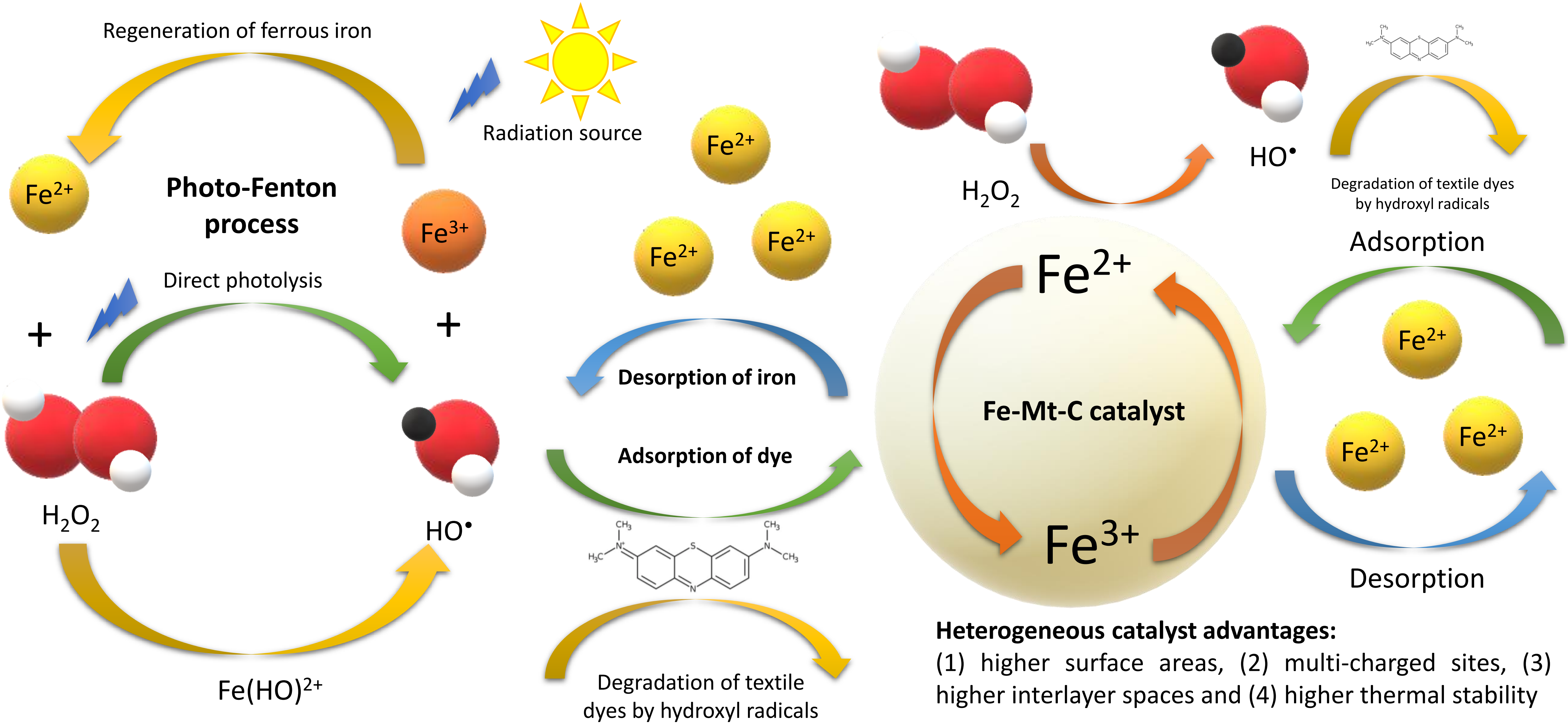
[c] Faculty of Engineering and Information Technology, Amran University, Amran, Yemen
[d] Laboratory REMTEX, High School of Textile and Clothing Industries, Casablanca, Morocco
[e] Royal Naval School, University Department, Boulevard Sour – Jdid, Casablanca, Morocco

Textile dye factory

River polluted by textile dyes


AOPs
HR-AOP
SR-AOP
Ozone
Fenton/ photo-Fenton
Homogeneous
Heterogeneous
Electro-Fenton
Oxalate
EDDS
EDTA
NTA
Clay
Zeolite
Fly ash
Ferrocene
Activation processes
Thermal activation
Alkaline activation
Radiation activation
Ozone treatments
HO^-/O_3 process
O_3/H_2O_2 process
UV/O_3 process
O_3/biological treatment

Mechanism of the heterogeneous photo-Fenton process



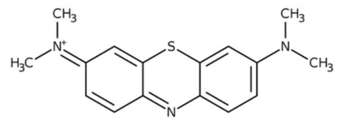
Heterogeneous catalyst advantages:

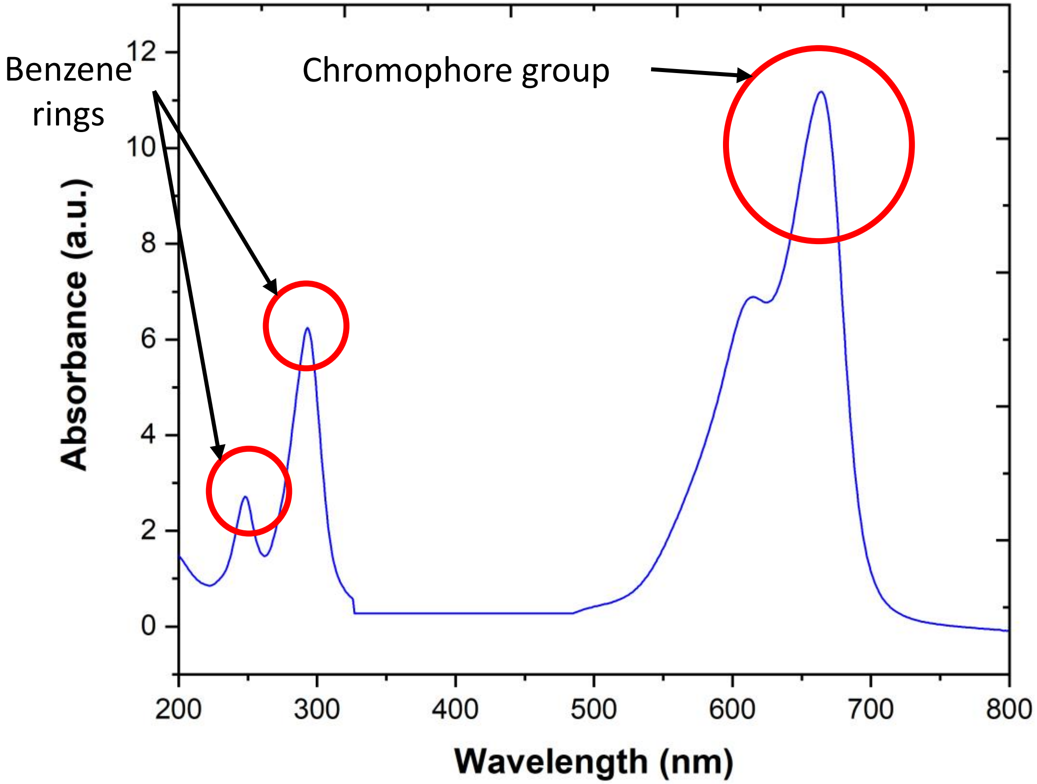
(1) higher surface areas, (2) multi-charged sites, (3) higher interlayer spaces and (4) higher thermal stability

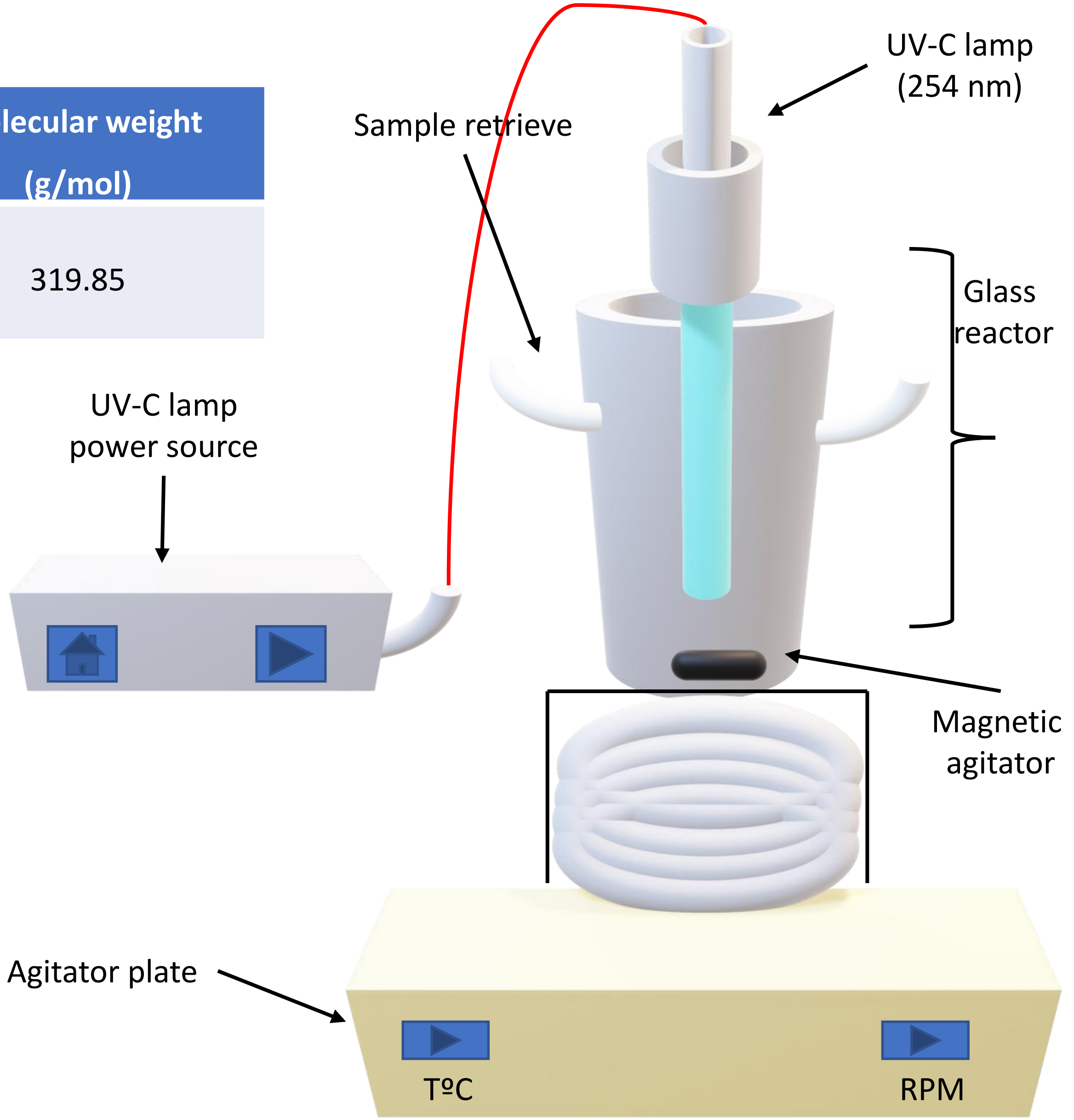
Objectives

The aim and novelty of this work is:

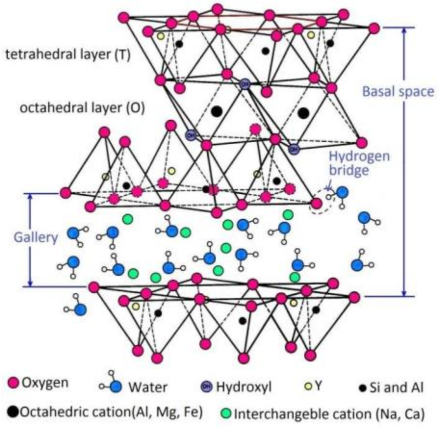
(1) to develop a new catalyst using a montmorillonite clay as a base material, to degrade a textile dye

Name	Chemical structure	λ_{max} (nm)	Molecular weight (g/mol)
Methylene blue (azo dye)		665, 300 and 250 nm	319.85

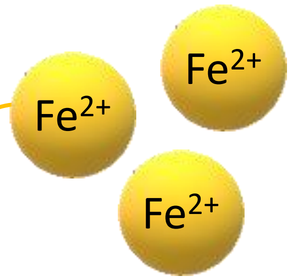




Catalyst preparation



Activated sodium bentonite
(Na-Mt)



- Agitation at 300 RPM/ 100ºC;
- Agitate untill all water is evapoarted

Incubator

- Dying for 24 h at 70ºC

Na-Mt

Fe(II)-Mt

- Calcination (500ºC/ 4 h)

Results and discussion

Characterization of Fe-BC catalyst

- The FTIR analysis (Figure 1(a)) showed similar peaks between the Na-Mt and Fe(II)-Mt. However, the Fe(II)-Mt reveled a significant structural change, with the disappearance of a peak at 1103.28 cm^{-1} and the appearance of a new peak at 528.49 cm^{-1}.

- The XRD patterns of both Na-Mt and catalyst Fe(II)-Mt are shown in Figure 1(b) , and the crystallographic parameters were evaluated by measuring the basal reflexions in the plane dhkl 001. The data reveled a significant shift associated with the reflection d001, from 14.01 Å to 9.92 Å, confirming the structural modifications that occurred on the Fe(II)-Mt after the calcination.

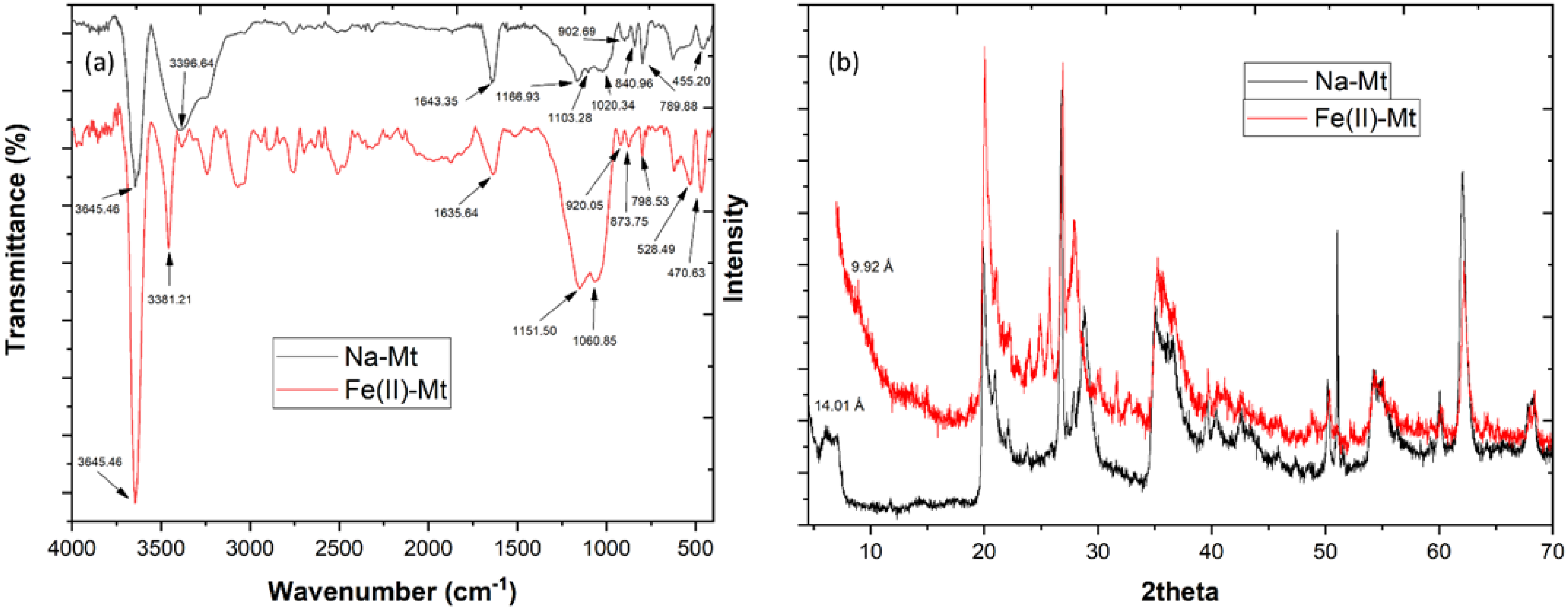


Figure 1. Analysis of Na-Mt and Fe(II)-Mt by (a) FTIR and (b) X-ray diffraction.

Results and discussion

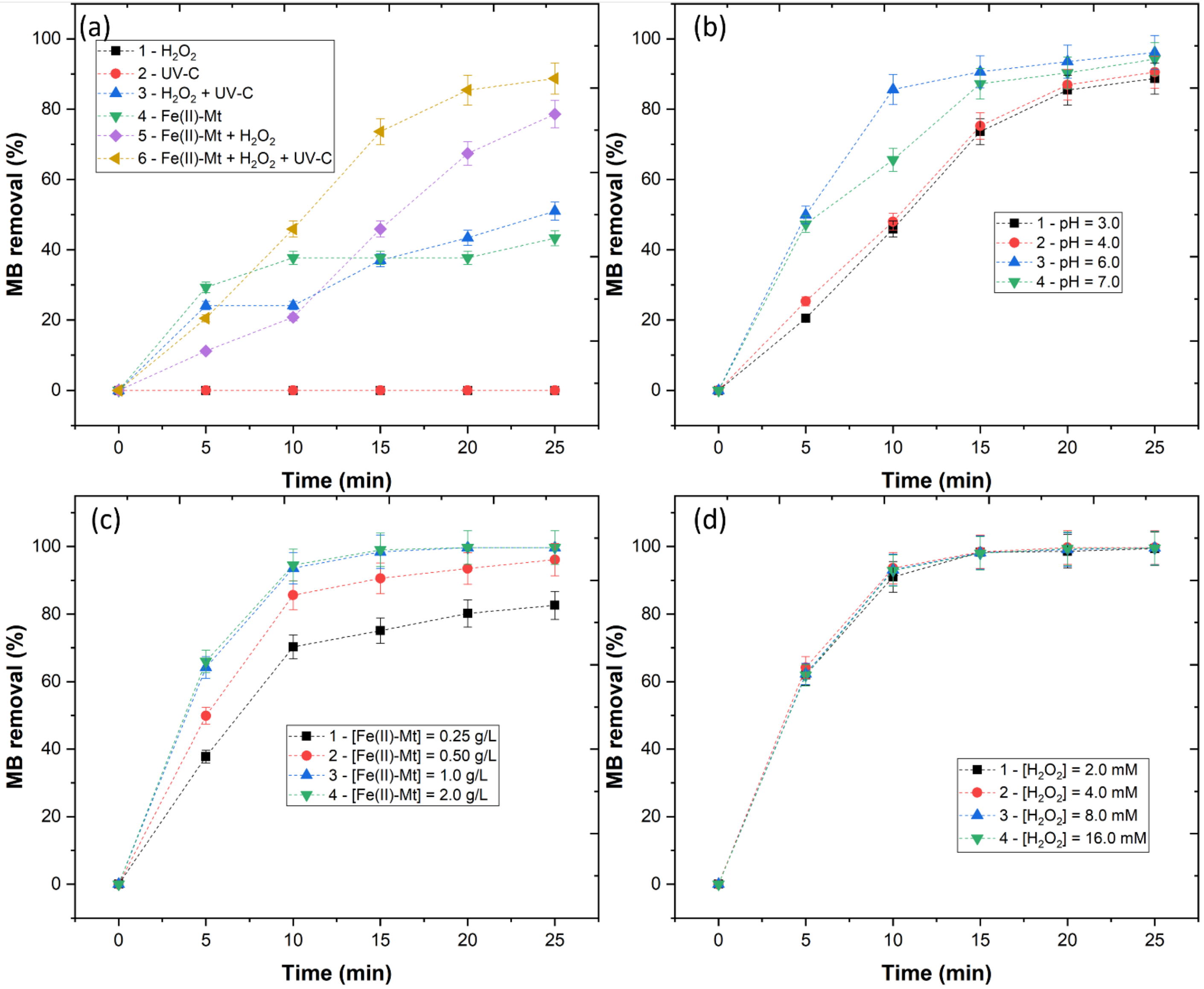


Figure 2. Removal of MB by (a) variation of AOPs, (b) variation of pH (3.0 – 7.0), (c) variation of Fe(II)-Mt catalyst concentration (0.25 2.0 g/L) and (d) variation of H2O2 concentration (2.0 – 16.0 mM).

- In Figure 2(a), six different AOPs were tested, with the following conditions: pH = 3.0, [Fe(II)-Mt 0.5M] = 0.5 g/L, [H_2O_2] = 4 mM, [MB] = 0.16 mM, radiation = UV-C (254 nm), time = 25 min;
- heterogeneous Fenton and photo-Fenton were applied, with results showing a MB removal of 78.6 and 88.7%. Clearly, the catalyst can convert the H_2O_2 and generate HO• radicals. This effect is enhanced with the application of UV radiation, thus heterogeneous photo-Fenton was selected as the best AOP;
- The pH was varied from 3.0 to 7.0 (Figure 2(b)). Results showed a MB removal of 88.7, 90.5, 96.1 and 94.2%, respectively for pH 3.0, 4.0, 6.0 and 7.0;
- The results in Figure 2(c) showed a MB removal of 82.6, 96.1, 99.7 and 99.7%, respectively for 0.25, 0.50, 1.0 and 2.0 g/L. As the catalyst concentration increased from 0.25 to 1.0 g/L, the production of HO• radicals increased, due to a higher content of Fe^{2+} present in solution;
- The H_2O_2 concentration was varied from 2.0 to 16.0 mM to access the effect of the oxidant concentration in heterogeneous photo-Fenton (Figure 2(d)). The results showed that the removal of MB was independent from the concentration of H_2O_2.

Catalyst reuse

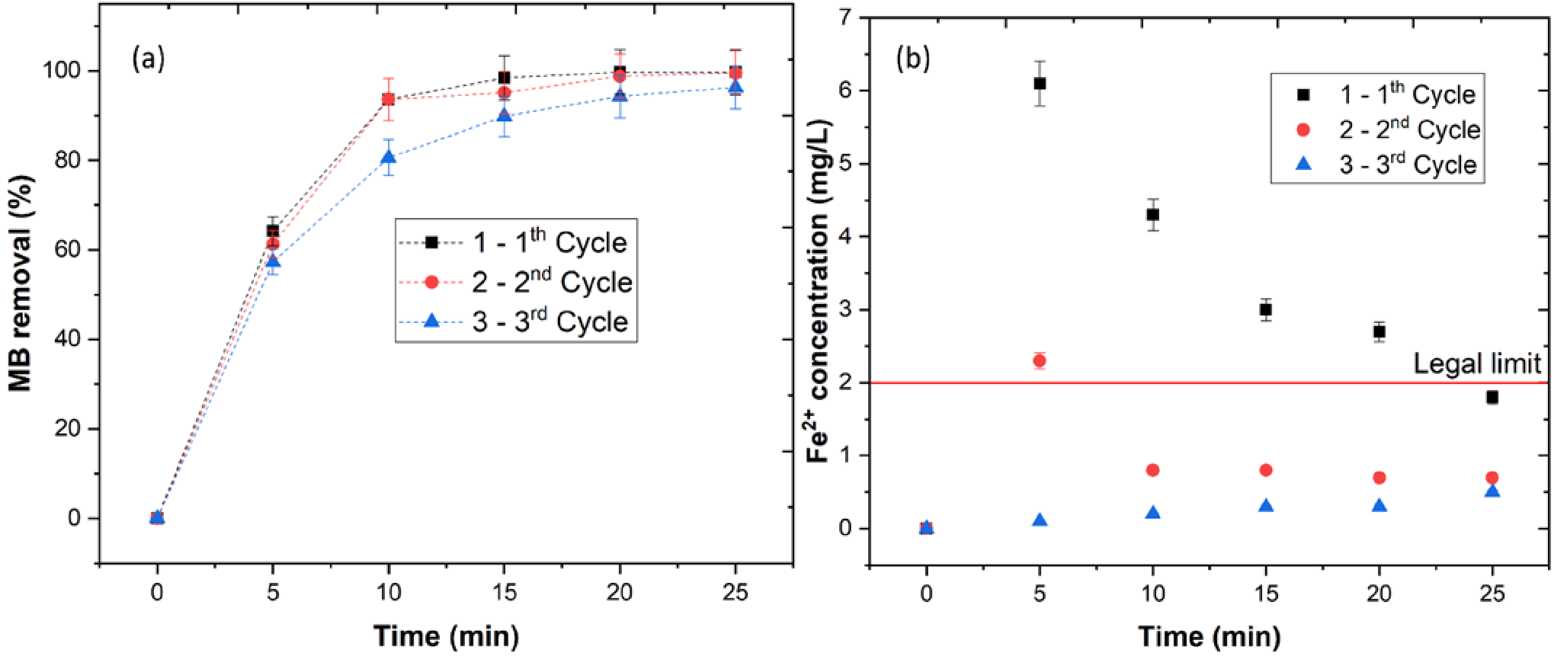


Figure 3. (a) Catalyst stability, (b) Fe^{2+} leaching concentration for 3 consecutive cycles.

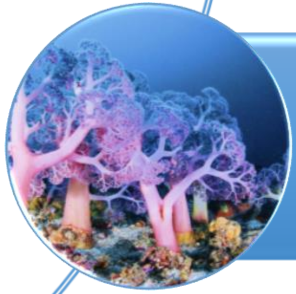
- 3 consecutive cycles were performed. The results in Figure 3(a) shows a MB removal of 99.7, 99.5 and 96.3%, respectively for the 1st, 2nd and 3rd cycles;
- The leaching concentration was determined during the 3 cycles (Figure 3(b)). These results showed a high Fe^{2+} release during the first 5 min, decreasing its concentration from 5 to 25 min;
- The final Fe^{2+} concentration values were observed to be far below the European Eco-nomic Community standards for discharge of treated waters – 2 mg L^{-1}.

Conclusions

Based in the results, it is concluded:

(1) that calcination of montmorillonite clays does not affect their structural integrity and allows the incorporation of Fe^{2+}

(2) that the heterogeneous photo-Fenton is the most efficient process in MB degradation



(3) that the catalyst can be reused for 3 consecutive cycles, decreasing the treatment costs and the iron is reabsorbed after each cycle

Acknowledgements

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FCT Fundação para a Ciência e a Tecnologia NORTE2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

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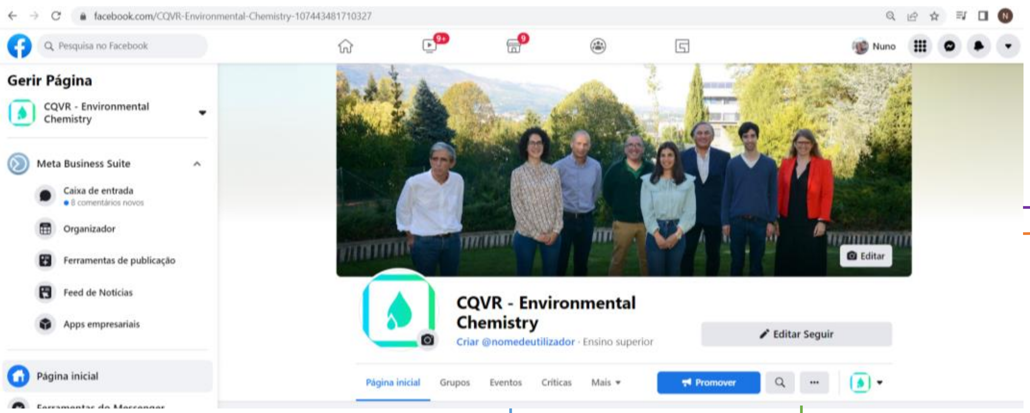

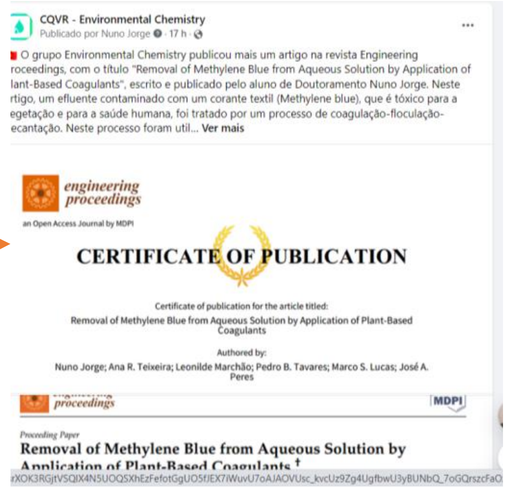

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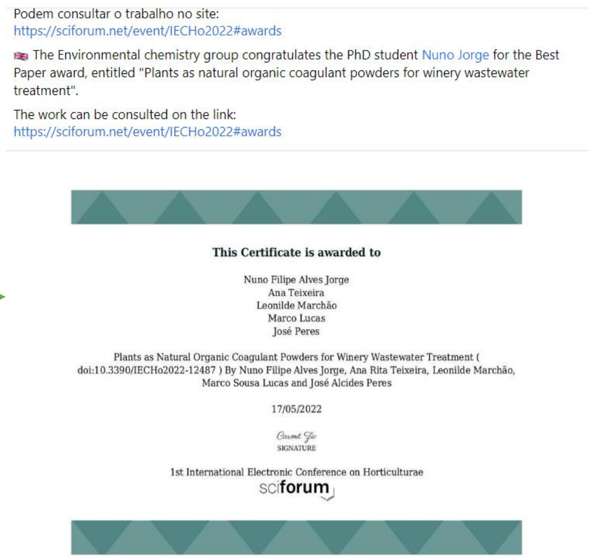

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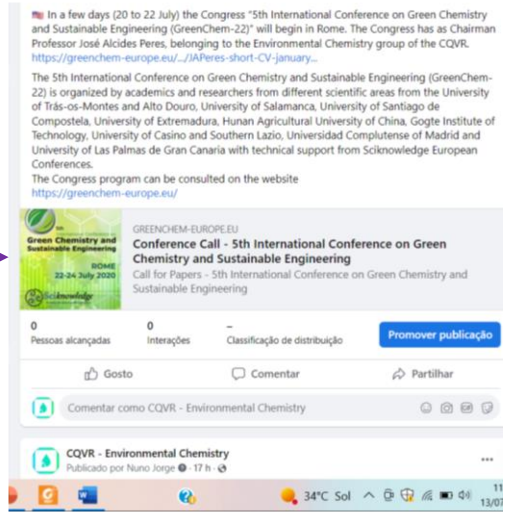

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